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U.S. ARMY

TEST & EVALUATION COMMAND

ATA-TR-63-4

FINAL REPORT OF ENGINEERING TESTS
USATECOM PROJECT NO. 4-4-1142-01
TAKEOFF AND LANDING CAPABILITIES OF THE
CARIBOU CV-2B AIRCRAFT ON UNPREPARED
SURFACES

(Similar to Air Force Project Rough Road Alpha)
September 1963

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ACTION BY HIGHER
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HEADQUARTERS
U.S. ARMY AVIATION TEST ACTIVITY
EDWARDS AFB, CALIFORNIA

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TABLE OF CONTENTS

SUMMARY

This test project was conducted by the U. S. Army Aviation Test Activity, Edwards Air Force Base, California, to determine the performance of CV-2B airplanes when utilizing surfaces and environments similar to those encountered during the Air Force Project Rough Road Alpha.

The areas used for these tests were the same ones used by the Air Force during Project Rough Road Alpha. They included the South Base runway at Edwards AFB, California; a soft clay runway at Harper's Dry Lake, California; and a soft sand runway at the Marine Corps Auxiliary Air Station, Yuma, Arizona. From these tests it is concluded that the takeoff and landing performance of the CV-2B airplane, when operating at its maximum gross weight of 28,500 pounds, is better than that of the C-130B and the C-123B, even when these airplanes are operating near minimum practical gross weights (see Tables III and IV, Test Results). The takeoff and landing performance of the CV-2B operating at maximum gross weight is either equal to or better than that of the JC-130B, the NC-130B, and the YC-123H. The CV-2B equipped with reversing propellers demonstrates landing performance that is considerably better than that of any of the airplanes tested during the Air Force Project Rough Road Alpha.

The tables on the following page summarize the takeoff and landing performance of the CV-2B.

These tests were accomplished using standard production-line CV-2B airplanes without modifications. The only airplane problem encountered during these tests was a high rate of wear of wheel bearings and axles during operation from a soft sand surface. Some propeller nicking and erosion occurred during operation from the sand surface; however, the propellers on the two test airplanes finished this program in serviceable condition. A better wheel bearing-axle seal must be developed and evaluated by service test before the CV-2B can be satisfactorily operated from sand runways for extended periods.

Analysis of the structural loads encountered revealed that all critical landing gear structural loads monitored during the project were well under limit design strength. No damage or parts consumption was encountered with the two test airplanes other than that of the wheel bearings and axles previously mentioned.

The use of reverse thrust during landing roll-out shortened the total distance required to clear a 50-foot obstacle by approximately 38 percent on the concrete and soft clay surfaces and by approximately 25 percent on the sand surface. The difference in percent improvement in landing performance resulted from the use of a more conservative technique on sand to minimize propeller blade erosion.

A 25-degree flap setting provided the optimum configuration for a takeoff from all surfaces. Both 15- and 30-degree flap settings produced longer total distances to clear 50 feet. A takeoff technique in which a full up elevator deflection was utilized from brake release until lift-off attitude was achieved produced maximum takeoff performance on all surfaces.

The small nose gear tires, size 7.50 x 10, were evaluated during the sand field operation and subsequently replaced with the larger nose gear tires, size 8.50 x 10, fitted with inner tubes. On the sand surface, nose wheel flotation was critical during small radius turns.

The contractor's airspeed position error data for the takeoff and landing configurations in the Operator's Manual did not represent the actual value encountered during takeoff and landing situations. The data collected during this project, together with the results presented in the AFFTC-TR-60-4, showed that a <u>negative</u> position error might be present under these conditions.

TABLE I

TAKEOFF PERFORMANCE SUMMARY

Standard Sea Level - No Wind Conditions

Aircraft	Gross Weight Lbs	Takeoff Distances - Feet: Ground Roll Surface Paved	Ground Roll Surface Sand	[illegible]	Total Distance to Clear 50 Ft Surface Paved	Total Distance to Clear 50 Ft Surface Sand	Total Distance to Clear 50 Ft Surface [illegible]	Recommended Airspeed - Knots: Recommended Flaps-%(°)	V Lift-off KIAS	V Lift-off KTAS	V 50 Feet KIAS	V 50 Feet KTAS
CV-28	28,500	[illegible]	875	[illegible]	[illegible]	1154	[illegible]	62(25)	—	57	—	58

TABLE II

LANDING PERFORMANCE SUMMARY

Standard Sea Level - No Wind Conditions

Aircraft	Gross Weight Lbs	Landing Distances - Feet: Ground Roll Surface Paved	Ground Roll Surface Sand	[illegible]	Total Distance to Clear 50 Ft Surface Paved	Total Distance to Clear 50 Ft Surface Sand	Total Distance to Clear 50 Ft Surface Clay	Recommended Airspeed - Knots: Recommended Flaps-%(°)	V 50 Feet KIAS	V 50 Feet KTAS	V Touchdown KIAS	V Touchdown KTAS
CV-28*	28,500	500	450	[illegible]	[illegible]	850	[illegible]	100(40)	—	65	—	62
CV-28**	28,500	825	[illegible]	[illegible]	[illegible]	1050	[illegible]	100(40)	—	65	—	[illegible]

*Use of Reversing propellers and Braking Action

**Use of Braking Action Only

NOTE: CV-28 performance at [illegible]

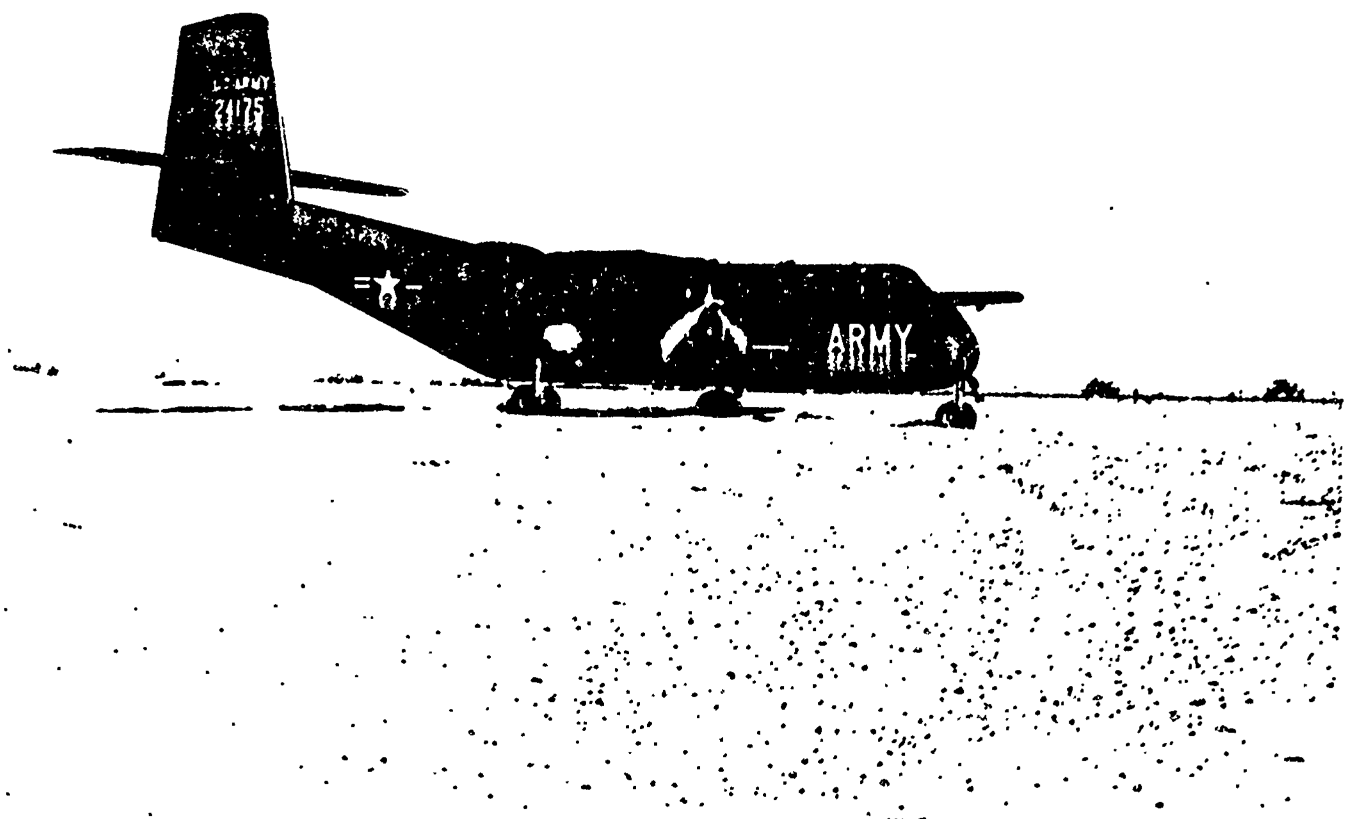


PHOTO 1 – CV-2B AIRPLANE OPERATING ON SOFT SAND

PART I GENERAL

A. References

A list of references will be found in Part III, Annex D.

B. Authority

Authority for the tests conducted in this report was received verbally from Hq, U.S. Army Test and Evaluation Command.

The purpose of this test program was to measure the takeoff and landing performance of the CV-2B airplane on unprepared surfaces.

C. Aircraft Description

Two CV-2B airplanes were utilized for the conduct of this project. Both were of recent manufacture and were manufactured by DeHavilland Aircraft of Canada. Both airplanes were operated in a standard service configuration with the exception of the test instrumentation which was installed to collect the data required to meet the objectives of the program. No landing gear doors or other panels were removed during operation at the unprepared sites, and all components of the landing gear were standard CV-2B parts. The airplanes were fitted with the Hamilton Standard propeller, Model 43D50-659, which allowed reverse pitch operation for improved braking. Engine power during reverse pitch operation was limited to 37.5 inches of manifold pressure which corresponded to 70 percent of the rated engine takeoff shaft horsepower.

Airplane, Serial Number 62-4175, was instrumented primarily to record the strains and loads in the critical members of the main and nose landing gear. These critical members were selected by DeHavilland Aircraft, and all were pin ended and tubular, thereby insuring accurate load measurements. The measured loads were reliable and accurate indicators of whether design limit loads were being exceeded either in the landing gear or in other portions of the airplane structure.

Airplane, Serial Number 62-4176, was used primarily to gather performance data. The airplane was instrumented and the instrumentation maintained by U.S. Army Aviation Test Activity personnel. Instrumentation included the sensitive gages necessary to determine power, speed, and atmospheric conditions. An oscillograph with appropriate pickups was also installed to record vertical and longitudinal acceleration at the center of gravity (C.G.). A detailed listing of the instrumentation installed in this airplane is contained in Part II of this report.

D. Background

Pursuant to a request from the Secretary of Defense to the Secretaries of the Army and Air Force, the U.S. Army Materiel Command was directed to conduct an "off runway" hardware test of the CV-2B Caribou airplane. The Secretary of Defense's request was intended to resolve the differences of opinion existing between services concerning the relative capabilities of the C-123, C-130, and CV-2B airplanes to operate from unprepared surfaces.

Since the USAF had already determined capabilities of the various C-123 and C-130 airplanes to operate from unprepared surfaces (see report of Project Rough Road Alpha, reference 1), it was agreed between the Department of the Army and the Department of the Air Force that the report of Project Rough Road Alpha (FTC-TDR-63-8) would be supplemented by an identical test of the CV-2B and that these reports together with the standard handbook data (brown book) would meet the Secretary of Defense's requirements.

By agreement between Lt Gen Dwight E. Beach, CRD, and Lt Gen Ben Harrell, ACSFOR, Col A. J. Rankin, President, Army Aviation Test Board, then on TDY with Office of Chief of Staff, U.S. Army, was appointed the Department of Army Project Officer. With the concurrence of CG, U.S. Army Materiel Command, and CG, U.S. Army Test and Evaluation Command, Lt Col R. J. Kennedy, Jr. was directed to conduct this test at U.S. Army Aviation Test Activity, Edwards AFB, California, supported by the U.S. Army Aviation Test Board, U.S. Army Aviation and Surface Materiel Command, 11th Air Assault Division, U.S. Army Aviation School, U.S. Army Engineering Waterways Experimental Station, DeHavilland Aircraft, and Hamilton Standard. The USAF requested through the Air Staff

Action Officer, Lt Col John Smith, Hq, USAF, authority to send Air Force observers to the test. This authority was granted; however, no USAF observers (per se) are known to have visited any of the test sites during the conduct of the tests.

Air Force support of this testing was obtained through Flight Scheduling Branch, Air Force Flight Test Center, Edwards AFB, California. This support included site scheduling, crash rescue equipment and services support, photographic support, weight and balance services and air traffic control as necessary in the Edwards Air Force Base area.

USAF SAC expressly approved the use of Harper's Dry Lake by the U.S. Army Aviation Test Activity as an unprepared surface test site.

The U.S. Marine Corps Auxiliary Air Station, Yuma, Arizona, permitted use of the sand area at that airfield that had been used for Project Rough Road Alpha and provided other normal airfield services and support.

E. Test Objectives

The objective of this test was to obtain data for the CV-2B airplane that would be representative of operation under the same unprepared field conditions as were used for the U.S. Air Force Project Rough Road Alpha tests of the C-130B, the C-123B, the JC-130B, the NC-130B (BLC), and the YC-123H airplanes. The results of the Air Force tests are presented in reference 1, Annex D.

F. Test Results

This report presents the results of the tests of the CV-2B conducted to determine operational capabilities of the airplane when operated from unprepared surfaces essentially identical to those utilized during the Air Force Project Rough Road Alpha tests. These tests were conducted from 20 July through 1 August 63, by the U.S. Army Aviation Test Activity, Edwards Air Force Base, California. Personnel from the following activities and agencies participated in the test: U.S. Army Aviation Test Board, U.S. Army Aviation and Surface Materiel Command, 11th Air Assault Division, U.S. Army Aviation School, U.S. Army Engineering Waterways Experimental Station, DeHavilland Aircraft, and Hamilton Standard. Observers were also present from Hq, U.S. Army Combat Developments Command and Hq, U.S. Army Test and Evaluation Command. A list of participants is included in Annex C.

The data presented in this report is in final form. No interim reports have been submitted.

Three types of runway surfaces were utilized for these tests: concrete, soft clay and soft sand. The concrete and soft clay sites were located in the vicinity of Edwards AFB, California, and the soft sand site was located at the Marine Corps Auxiliary Air Station, Yuma, Arizona. The tests were conducted to determine the representative performance available from the CV-2B airplane operating at maximum gross weight (28,500 pounds) under the runway surface conditions listed. The structural loads induced in the critical members of the landing gear were also recorded.

All data presented in this report is considered to be representative of typical field operation. For the conditions of every performance landing data point presented in this report, the airplane could be taxied unassisted after making a complete stop following the landing roll-out.

General

The two test airplanes were operated on a paved surface to obtain representative data for the 28,500 pound gross weight prior to testing on soft clay and soft sand runway surfaces. The CV-2B has a tapering center of gravity versus gross weight envelope, and the center of gravity was established at the mid point (35 percent mean aerodynamic chord) at the gross weight condition during the tests (28,500 pounds). The main tire pressures used during the conduct of these tests were 40 pounds per square inch (psi), the maximum value specified by TO 55-1510-206-20. No attempt was made to evaluate the effect of changing tire pressure or to optimize tire pressure during these tests.

The soft sand site used in these tests represented the most severe condition that was encountered. The sand at this site was so soft that standard motor vehicles could not be operated on its surface.

At both the soft clay and the soft sand sites, visibility from the cockpit during landings in which reverse thrust was utilized was severly reduced due to blowing dust and sand. When the airplane stopped within this cloud of blowing dust or sand, taxi operations were curtailed until the resulting cloud dissipated.

No airframe or apparent engine damage was sustained by either test airplane as a result of the tests. Fuselage clearances were ample even in the soft sand. Wheel bearings proved to be the major wear item during operations at the soft sand site, and several sets had to be replaced. The wheel bearing and axle seals were inadequate in preventing sand entry. It was evident during the operation in the soft sand site that propeller erosion was higher than normal.

No attempt was made during this limited project to evaluate the minimum soil strength that would support CV-2B operations. During the course of the project, the effect of using the smallest tires available in the supply system for the nose gear of the CV-2B (7.50 x 10) was evaluated. This was done at the soft sand site since it was obvious that the soft clay site presented no difficulties for the CV-2B operation.

Ground Handling

Ground handling characteristics were evaluated on concrete, soft clay and soft sand with the following results:

1. Concrete surface - Ground handling qualities of the CV-2B on concrete were excellent. Eight hundred to one thousand engine rpm was sufficient to keep the airplane moving with light braking as required to control taxi speed. Nose wheel steering was effective in maintaining directional control. Taxi procedures as specified in the "Operator's Manual, AC-1 Aircraft" are applicable and adequate.

2. Clay surface - Ground handling characteristics on a clay surface were unchanged from those observed on concrete except that an increased average power level was required to maintain taxi speed due to the increased rolling resistance and irregularity of the clay surface. The additional power increment required was not excessive and was acceptable for continuous taxi operations.

3. Soft sand surface - Ground handling characteristics deteriorated on the soft sand surface. This was especially evident during small radius taxiing turns. Heavy braking did result in rutting 4 to 8 inches deep during landing rollout, and braking was not applied to a complete stop but was moderated so that approximately the final 5 knots of taxi speed was dissipated by ground friction alone. This was necessary to prevent sand from piling up in front of the wheels after the airplane came to a stop.

As a result of the above braking technique, all landings and takeoffs on sand for which performance parameters were obtained were completed without immobilization of the airplane.

Installation of the smaller nose gear tires during testing at the Yuma Marine Corps Auxiliary Air Station soft sand test site showed that these tires (7.50 x 10) had insufficient flotation to allow practical use on that surface. No particular problem was encountered while taking off and landing, but taxiing operations were characterized by the nose wheel plowing soft sand areas during nose wheel steering operations and the resulting sand pile-up caused a loss of directional control and in some cases caused the airplane to become immobilized. After each immobilization, the airplane was taxiled out of ruts after removing sand from in front of the nose gear. Due to the improved flotation characteristics of the large nose gear tires, it was determined that large nose gear tires should be fitted during operation from this type of surface, which would permit operation from sand surfaces.

The standard nose wheel bearing dust cover installed on the test airplanes was

not effective in keeping sand out of the bearings. On one occasion, the nose wheel bearings on test airplane Serial Number 62-4175 were rendered unserviceable after one takeoff and one landing on the sand surface because of sand penetration into the bearings.

Due to sand ingestion, the nose wheel axle on airplane Serial Number 62-4175 was found to be scored and galled after 6 landings and takeoffs on the sand surface.

The small 7.50 x 10 tubeless tires installed on the nose gear of airplane Serial Number 62-4175, in one instance, had a complete loss of air when the tire bead was forced from the rim. This was caused by a side load during taxi. Skidding during landing, takeoff and taxi caused side loads which forced the tire away from the rim, causing, in one case, a complete loss of air from the left nose wheel tire. This condition warrants the use of tube tires for all operations.

Reverse thrust up to maximum reverse power was ineffective in freeing the airplane once it was immobilized during taxiing operation. The only solution was to hand dig the wheels free of the sand accumulation after which forward thrust was successful in extricating the airplane.

Takeoff Performance

The results of the takeoff performance tests conducted, including the similar values encountered for the various airplanes used during the U.S. Air Force Project Rough Road Alpha test, are presented in the table on page 6 (Table III).

The results of these tests show that the CV-2B performance at maximum gross weight is equal to or better than the performance of the heavier airplanes operating under severely reduced gross weight conditions and resulted in no structural damage to the airplane.

The data analysis technique used to reduce the test data to standard sea-level no-wind conditions was the same as that used for Project Rough Road Alpha (see AFFTC Technical Note R-12, "Standardization of Takeoff Performance Measurements for Airplanes," author, K. J. Lush.)

Minimum Run Takeoffs:

Minimum run takeoffs were easily accomplished on all three surfaces. Operator's Manual procedures were used with one minor exception. The exception was that maximum performance was achieved by an application of full aft control column movement prior to achieving elevator effectiveness speed during the takeoff roll and by holding the column full aft until the airplane rotated to lift-off attitude. When a 25-degree flap setting is used at the gross weights and C.G.'s tested, this takeoff technique is not difficult and the correct climb attitude may be easily established. When the above technique was utilized, airplane rotation occurred at approximately 56 to 57 knots indicated airspeed depending upon gross weight and lift-off occurred at 58 to 60 knots indicated airspeed. A climb attitude was easily established with minimum control movement, and minimum distance was achieved by not allowing lift-off indicated airspeed to increase more than 5 or 6 knots as the airplane climbed through 50 feet.

Special Takeoff Considerations Depending Upon Runway Surface:

Soft Clay:

The tests conducted on the soft clay surface yielded the following information in addition to the performance data. The 25-degree flap setting was determined to be the optimum flap setting for takeoff, and the use of a full aft control column from brake release produced minimum takeoff distances. The results of the test revealed that the use of 15-degree flap settings on this surface increased takeoff distances through 50 feet by approximately 120 feet.

A 30-degree takeoff flap setting used on this surface resulted in a slow airplane acceleration rate and increased the ground roll approximately 100 feet.

Soft Sand:

Takeoffs from soft sand required no special considerations other than a

slight increase in effort to maintain directional control of the airplane until lift-off. As with the other surfaces, a full aft yoke from brake release to the achievement of attitude produced maximum performance with the airplane.

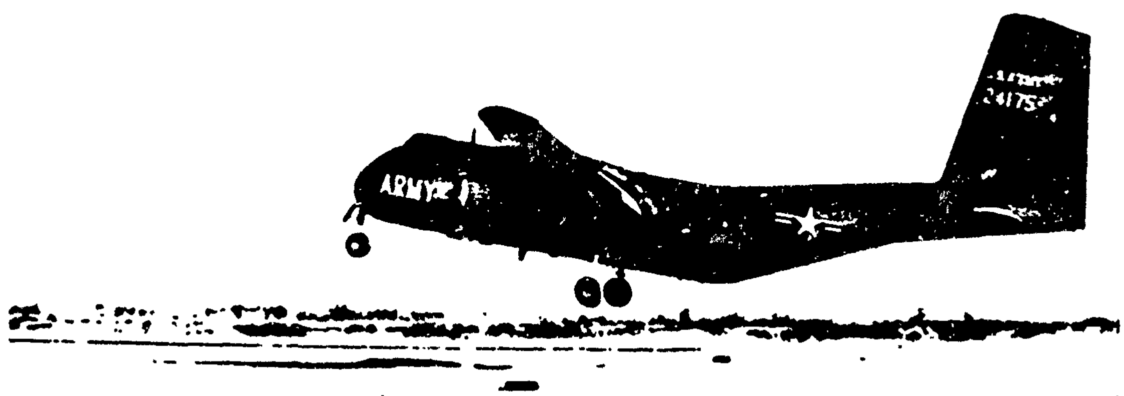
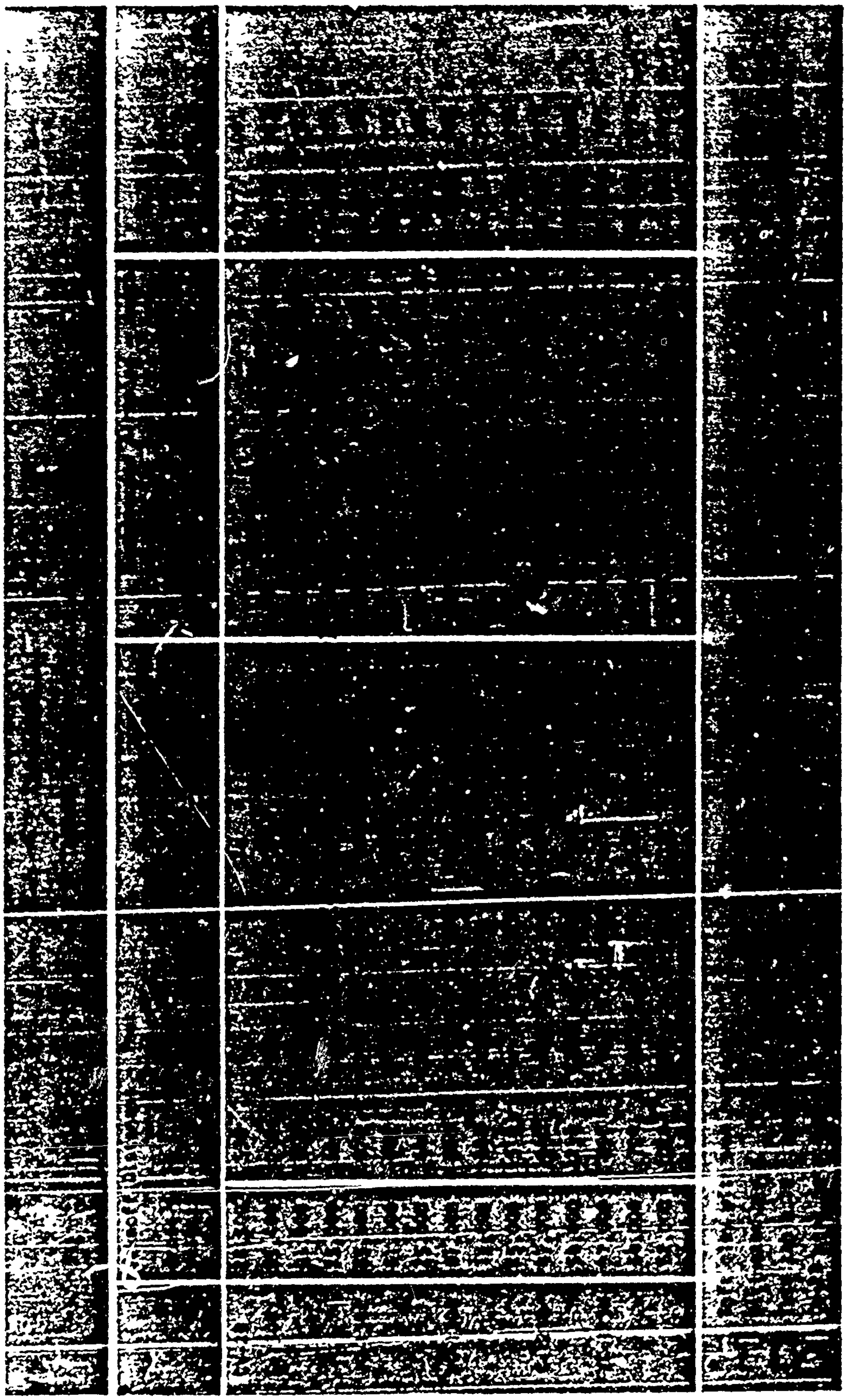


PHOTO 2 – TAKEOFF ON UNPREPARED SAND SURFACE – YUMA, ARIZONA



Landing Performance

Landing performance data on the various surfaces was accumulated by using normal Operator's Manual recommended minimum run landing techniques. The technique utilized a 40-degree flap setting, constant airspeed on final approach, an idle power setting, and the use of a reasonable rate control column deflection to flare the airplane into landing attitude. The results of these tests are presented in Table IV on the following page. Reverse propeller pitch was used after the nose gear was on the ground for the remainder of the landing roll for thos data points so noted. The braking action used during these tests was the technique recommended by the Operator's Manual and was qualitatively evaluated by the project pilots as moderate to heavy braking. It should be noted that the original set of tires was utilized for both airplanes throughout the conduct of this program. These tires were still serviceable at the end of the program. High wheel and tire temperatures due to heavy braking were not encountered at any time.

Special Landing Considerations Depending Upon Runway Surface:

Soft Clay:

Landings on the soft clay surface were easily accomplished by using the same techniques as were used on a dry concrete surface. Landing gear structural loads were similar to or less than the loads encountered during similar operations from dry concrete. (See Table V) Total distances were decreased over the same types of landings conducted on dry concrete due to the braking effect obtained in the dust on the soft clay surface. The brakes can be locked and the wheels skidded in the dust without the condition being detected by the pilot in the cockpit. Minimum ground roll distances were obtained by a combination of propeller reversing and moderate to heavy braking.

Soft Sand:

Landings on the soft sand site were accomplished by using the same techniques from flare to touchdown as were used on the other surfaces. After touchdown, however, maximum braking effect was obtained by locking the wheels with the brakes and allowing the main gear to plow through the soft sand. This resulted in an energy transfer from the airplane into the sand and was effective in slowing the airplane. There was insufficient rolling friction drag from the sand to slow the airplane effectively without the use of wheel brakes. In one case, 800 feet of ground roll was used without brakes and the airplane slowed only 20 feet per second.

PHOTO 3 – LANDING ON UNPREPARED SAND SURFACE

TABLE IV

LANDING PERFORMANCE SUMMARY **

Standard Sea Level - No Wind Conditions

Aircraft	Gross Weight Lbs	To Clear 50 Ft Surface: Paved	To Clear 50 Ft Surface: Sand	To Clear 50 Ft Surface: Clay	Landing Distances - Feet, Ground Roll Surface: Paved	Ground Roll Surface: Sand	Ground Roll Surface: Clay*	Recommended Flaps-%(°)	Recommended Airspeed - Knots, V 50 Feet: KIAS	V 50 Feet: KTAS	V Touchdown: KIAS	V Touchdown: KTAS	Basic Test Wt	% Wt. Ratio of x 100
CV-28 [1]	28,500	925	850	925	500	450	485	100(40)	--	65.0	--	62.0	19,777	100%
CV-28 [2]	28,500	1250	1050	194	825	650	755	100(40)	--	65.0	--	61.0	19,777	100%
C-130B	85,000	1500	1400	1380	800	700	680	100(36)	85.5	85.5	77.5	80.0	70,570	63%
	01,000	1870	1780	--	1080	950	--	100(36)	92.0	93.0	84.0	87.0	70,750	75%
	25,000	2720	2510	2100(2850)	1620	1410	1000(1750)	100(36)	101.5	103.5	93.0	97.0	70,570	93%
JC-130B	85,000	1400	--	--	750	--	--	100(50)	80.5	80.5	71.0	77.0	79,017	63%
	01,000	1630	--	--	910	--	--	100(50)	88.0	87.0	77.0	83.5	79,017	75%
	25,000	2400	--	--	1400	--	--	100(50)	98.0	97.0	87.0	93.0	79,017	93%
HC-130B	01,000	1150	1650	1650	650	650	650	78(70)	--	72.0	--	71.0	81,439	63%
	15,000	[illegible]	1980	--	--	930	--	78(70)	--	75.0	--	74.0	81,439	75%
	25,000	1500	--	1900	900	--	900	78(70)	--	78.0	--	77.0	81,439	93%
C-123B	47,000	1500	1270	1355	760	510	615	100(60)	81.0	83.9	74.0	76.0	34,407	87%
	54,000	1730	--	1410	970	--	650	100(60)	87.0	90.0	79.0	81.0	34,407	100%
YC-123H	47,000	1250	1170	1120	700	620	570	100(60)	79.0	76.0	--	75.5	40,086	76%
	54,000	1370	1270	1190	820	720	640	100(60)	85.0	78.0	--	78.0	40,086	87%
	62,000	1550	1400	1310	1000	850	760	100(60)	90.0	82.0	--	82.0	40,086	100%

* Soft clay with wet surface

** This table is a reproduction of the table presented in FTC-TDR-62-8, page 18, (Project Rough Road Alpha), with the CV-28 test data added.

1 Reversing Propellers and Braking Action

2 Braking Action Only

A more conservative reverse thrust technique was used during operations from sand than from the other two surfaces in order to minimize the probability of propeller and engine damage. Minimum ground roll distances were obtained by a combination of reversing and maximum brake application.

TABLE V

UNPREPARED FIELD OPERATION

SUMMARY OF PEAK LANDING GEAR LOADS

	Landing Gear Loads (Loads Presented in Percent of the Design Limit Load)				
Runway Surface	Right Main Gear Drag Strut	Left Main Gear Drag Strut	Right Main Gear Shortening Strut	Left Main Gear Shortening Strut	Nose Gear Drag Strut
Soft Clay	40.9% (Landing Roll)	45.1% (Landing Roll)	70.2% (Touchdown)	52.6% (Landing Roll)	37.0% (Touchdown)
Soft Sand	46.2% (Landing Roll)	40% (Touchdown)	62.8% (Touchdown)	57.1% (Touchdown)	50.7% (Pulling out of rut)

Miscellaneous

It was noted during this program that there may be a negative position error present in the airspeed systems during takeoff and landing operations in ground effect (see Figure 1, Part II). This conclusion is borne out by the results of the YAC-1 test conducted by the Air Force Flight Test Center and should be thoroughly investigated in order that proper approach and touchdown speeds may be recommended for landing operations. The position error data presented in the Operator's Manual is not adequate to determine position error accurately during takeoff and landing operations.

This particular area is critical since each additional knot of speed at lift-off causes an increase in ground roll of approximately 30 feet and each additional knot of airspeed at touchdown increases ground roll 60 feet.

With the material in the above paragraph taken into consideration, it is also concluded that the standard airplane airspeed indicator is inadequate to allow accurate control of the airplane during landing and takeoff.

The results of these tests indicated that the takeoff data presented in the Operator's Manual as results of AFFTC tests and contractor tests was considerably conservative when compared to the actual performance available from the airplane. Sufficient testing should be conducted with a CV-2B airplane to provide Manual takeoff and landing data that is accurate for an airplane equipped with reversing propellers.

PHOTO 4 – CV-2B WHEEL RUTS IN SAND

PHOTO 5
CV-2B MAIN GEAR

G. CONCLUSIONS

As a result of the information presented in Section F of this report, it is concluded that:

1. The takeoff and landing performance of the CV-2B airplane operating at maximum gross weight exceeds that of the C-130B, JC-130B, NC-130B, and the C-123B.

2. The takeoff and landing performance of the CV-2B operations at maximum gross weight exceeds that of the YC-123H at all gross weights and conditions tested except for takeoff in soft sand at a gross weight of 47,000 pounds. At this gross weight, the YC-123H could carry little, if any, payload on a normal combat mission.

3. The airframe structure of the CV-2B at maximum gross weight is suitable for repetitive operations on unprepared surfaces.

4. A 25-degree flap setting is optimum to obtain maximum takeoff performance from any surface.

5. The standard wheel bearing seals are not adequate to prevent sand penetration of the wheel bearings when operating on a soft sand surface.

6. An increased rate of propeller erosion should be expected during operation from a sand surface.

7. Installation of a more sensitive airspeed indicator would enhance the capability of the pilot to obtain consistent performance during both takeoffs and landings.

8. The airspeed position error data for the takeoff and landing configurations currently presented in the Operator's Manual is not accurate for the actual takeoff and landing situation and should be determined to allow obtaining optimum performance.

H. RECOMMENDATIONS

1. It is recommended that 25-degree flaps be used as standard takeoff flaps for any surface when maximum performance is to be obtained.

2. It is recommended that the large nose wheel tires (8.50 x 10) with tubes be fitted to the CV-2B for operation under all conditions.

3. It is recommended that improved seals be fitted to the bearings of the main and nose landing gear which will prevent the entry of sand during unprepared site operation.

4. It is recommended that sensitive airspeed indicators be installed in place of the present airspeed gages in order that consistent performance ma obtained during both takeoff and lar

Reviewed and Approved By:

Richard J. Kennedy Jr.

RICHARD J. KENNEDY, JR.
Lieutenant Colonel, TC
Commanding

PART II

TEST DATA

TEST DATA

A. Data collection and analysis methods.

1. The takeoff and landing data was taken by means of instrumentation installed in the test airplane and by a Fairchild Flight Analyzer. Installed instrumentation in each airplane included:

Airplane Serial Number 62-4175:

- Sensitive airspeed indicator
- Calibrated altimeter
- Nose gear drag strut load
- Left and right main gear drag strut loads
- Left and right main gear shortening strut loads
- CG normal acceleration
- CG longitudinal acceleration

Airplane Serial Number 62-4176:

- Sensitive copilot's airspeed indicator (boom airspeed system)
- Sensitive engineer's panel airspeed indicator (boom airspeed system)
- Calibrated engineer's panel altimeter (boom airspeed system)
- Sensitive pilot's airspeed indicator (ship's system)

Engineer's Panel:

- Free air temperature
- Sensitive Tachometers (left and right)
- Sensitive manifold pressure (left and right)
- Carburetor air temperature (left and right)

Oscillograph:

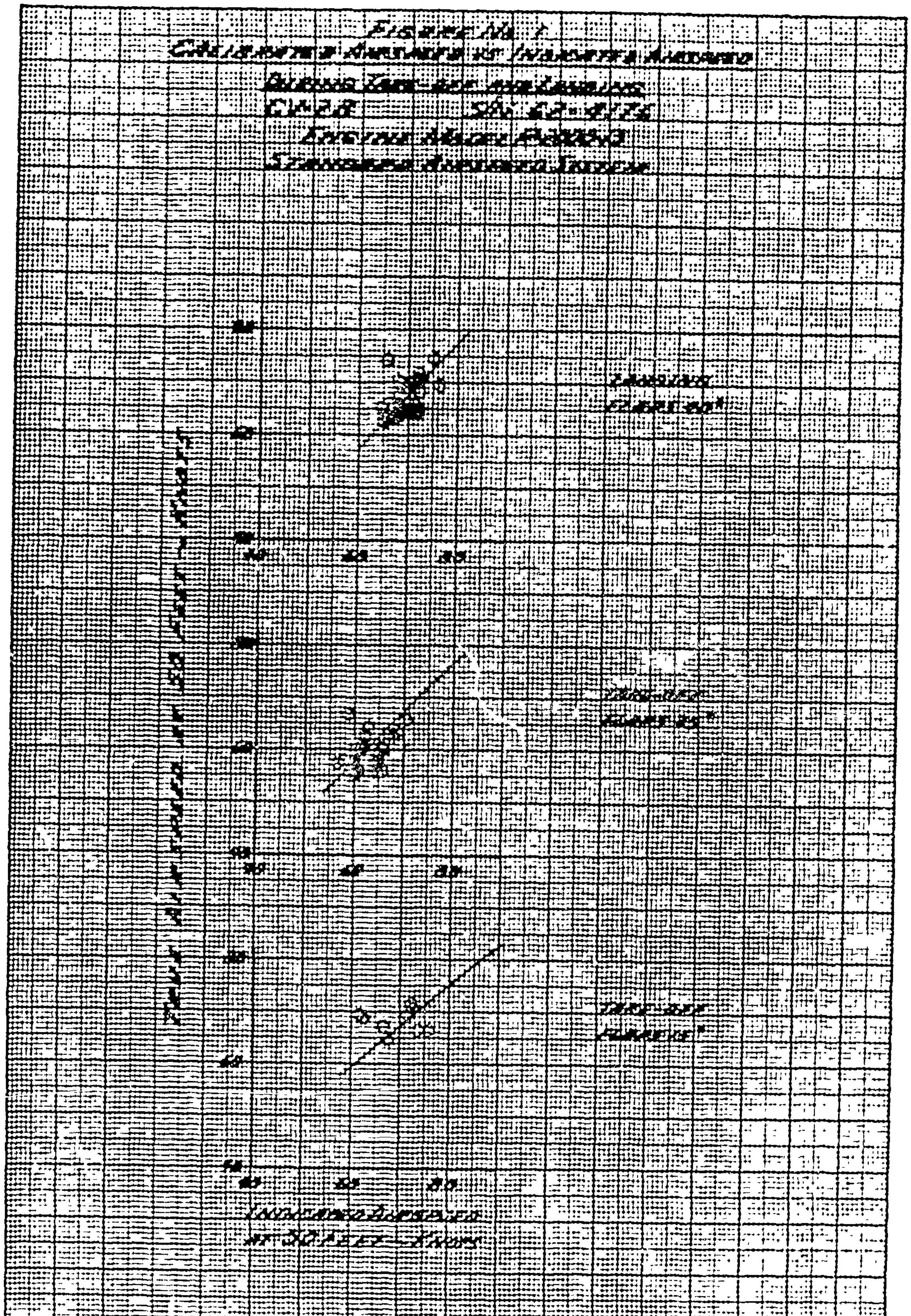
- CG normal acceleration
- CG lateral acceleration

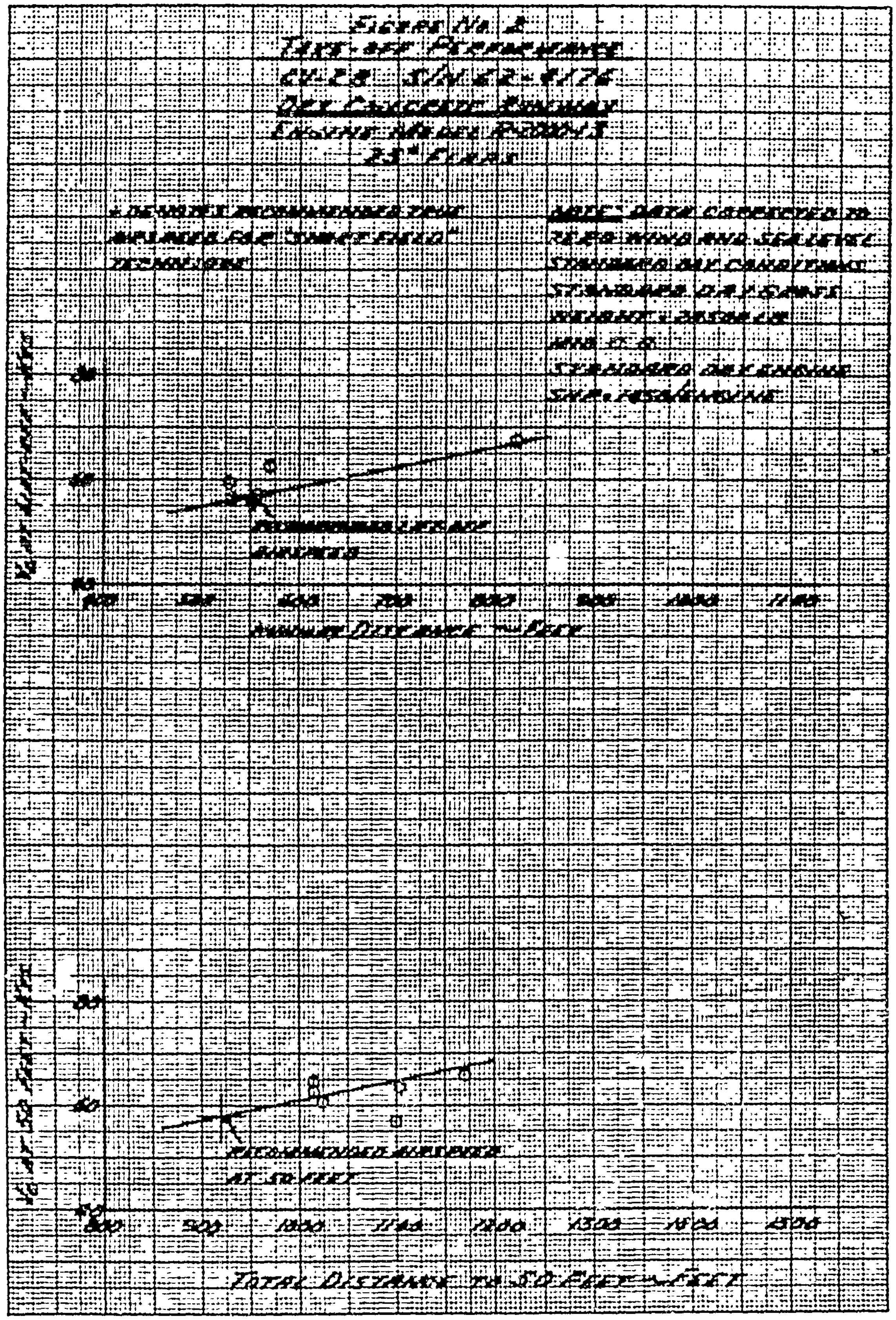
2. The Fairchild Flight Analyzer was set up over surveyed locations at each test site. From analysis of the resulting plates, the distance, speed, and altitude information for test conditions was determined.

3. All takeoff data was reduced to sea-level, standard-day, no-wind conditions by the use of the methods outlined in AFFTC-TN-R-12, by Mr. Kenneth J. Lush, entitled "Standardization of Takeoff Perfromance Measurements for Airplanes."

4. All landing data was reduced to sea-level, no-wing, standard-day conditions by the use of the methods presented in Chapter 6 of USAF-TR-6273 entitled "Flight Test Engineering Manual."

B. FINAL PLOTS




Take-off Performance
Total Distance to 50 Feet ~ Feet

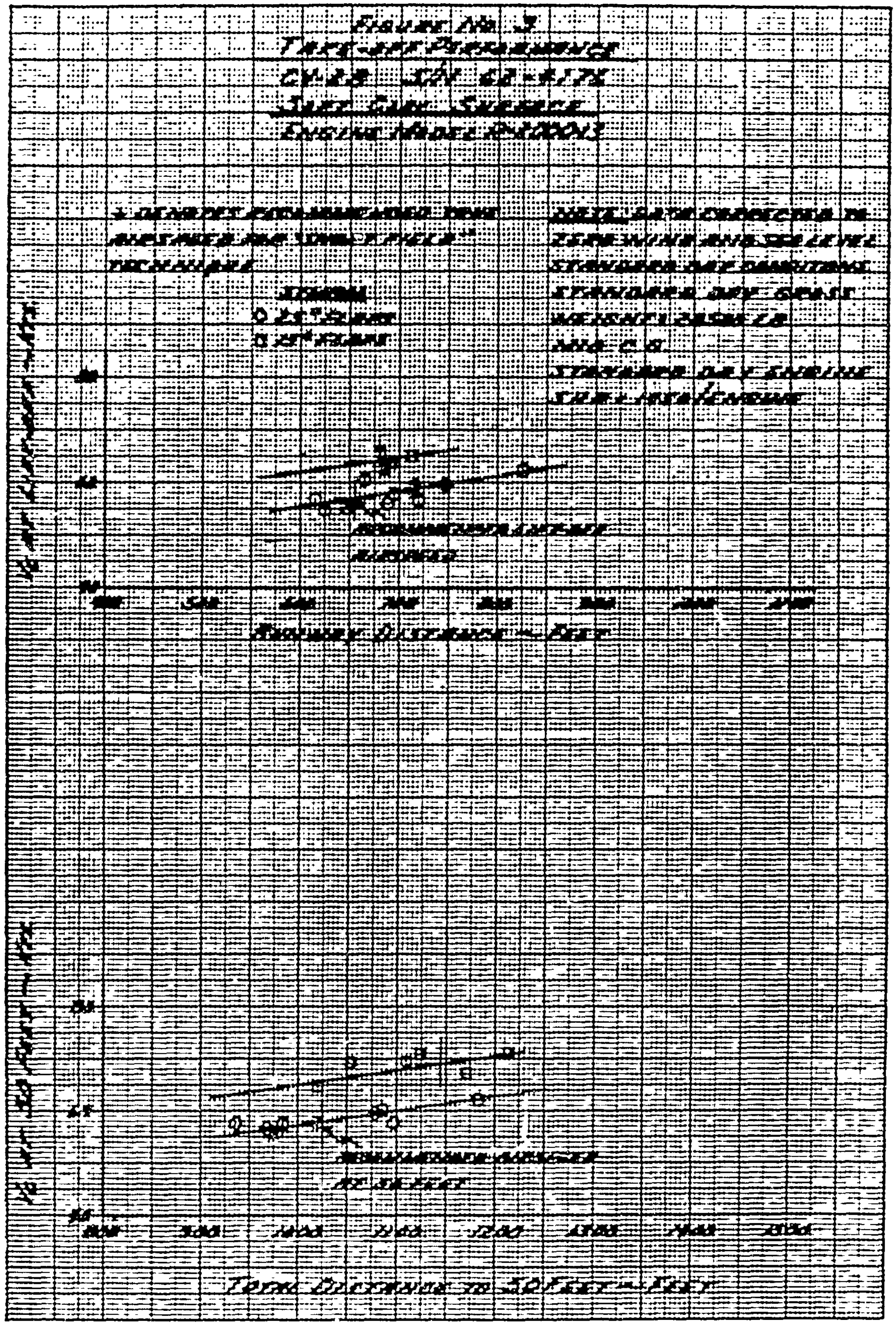
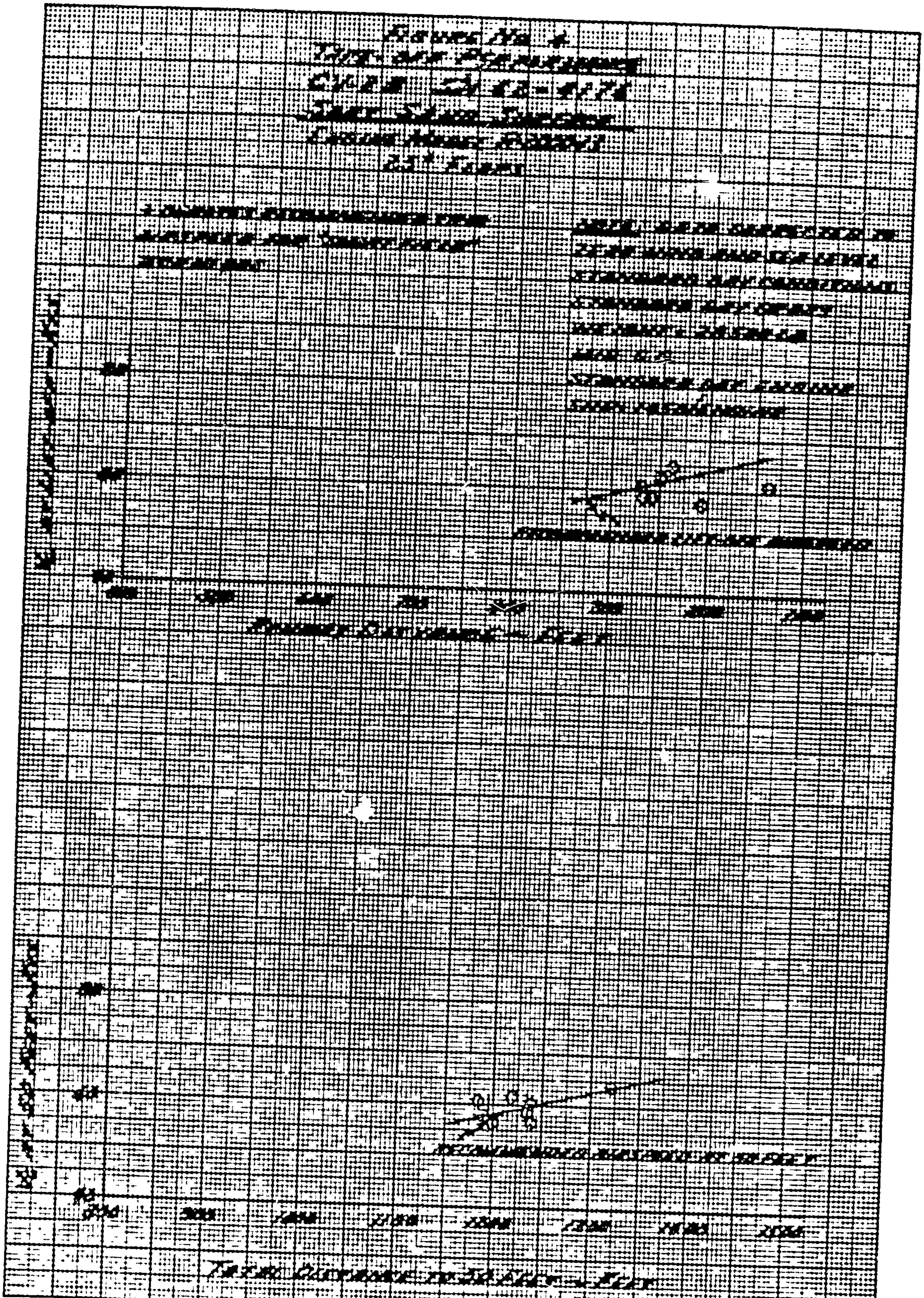
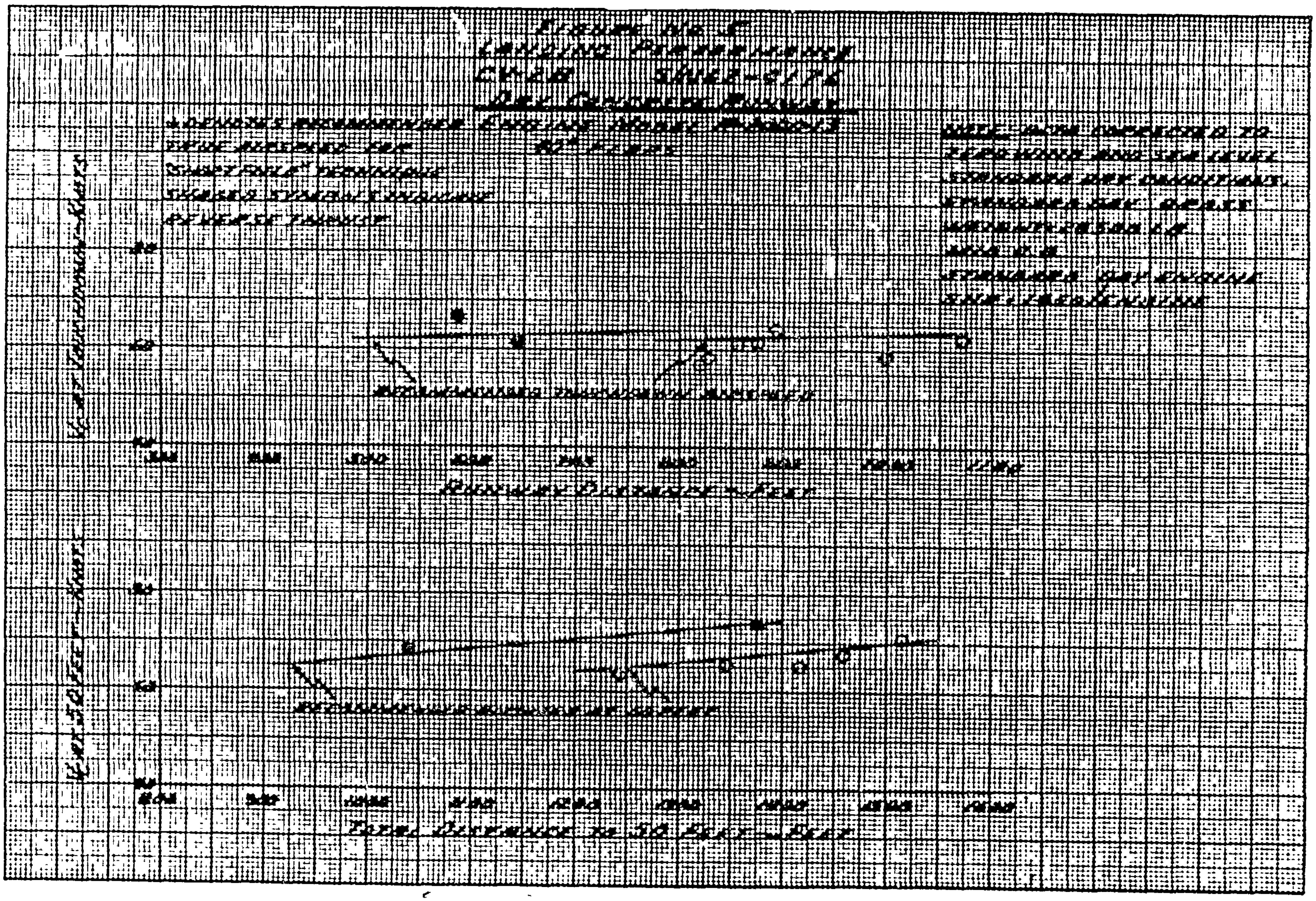


Figure No. 3
Take-off Performance





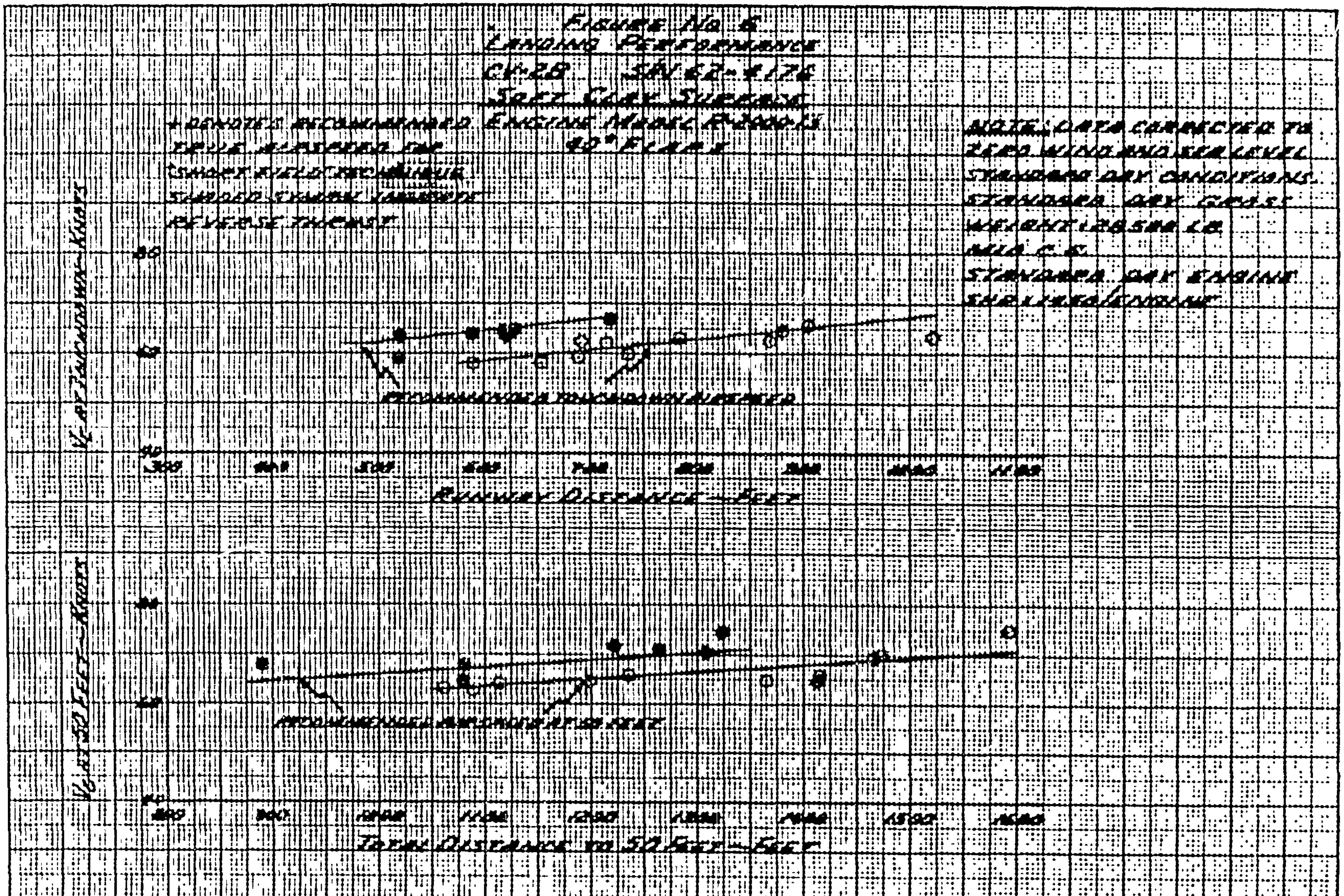
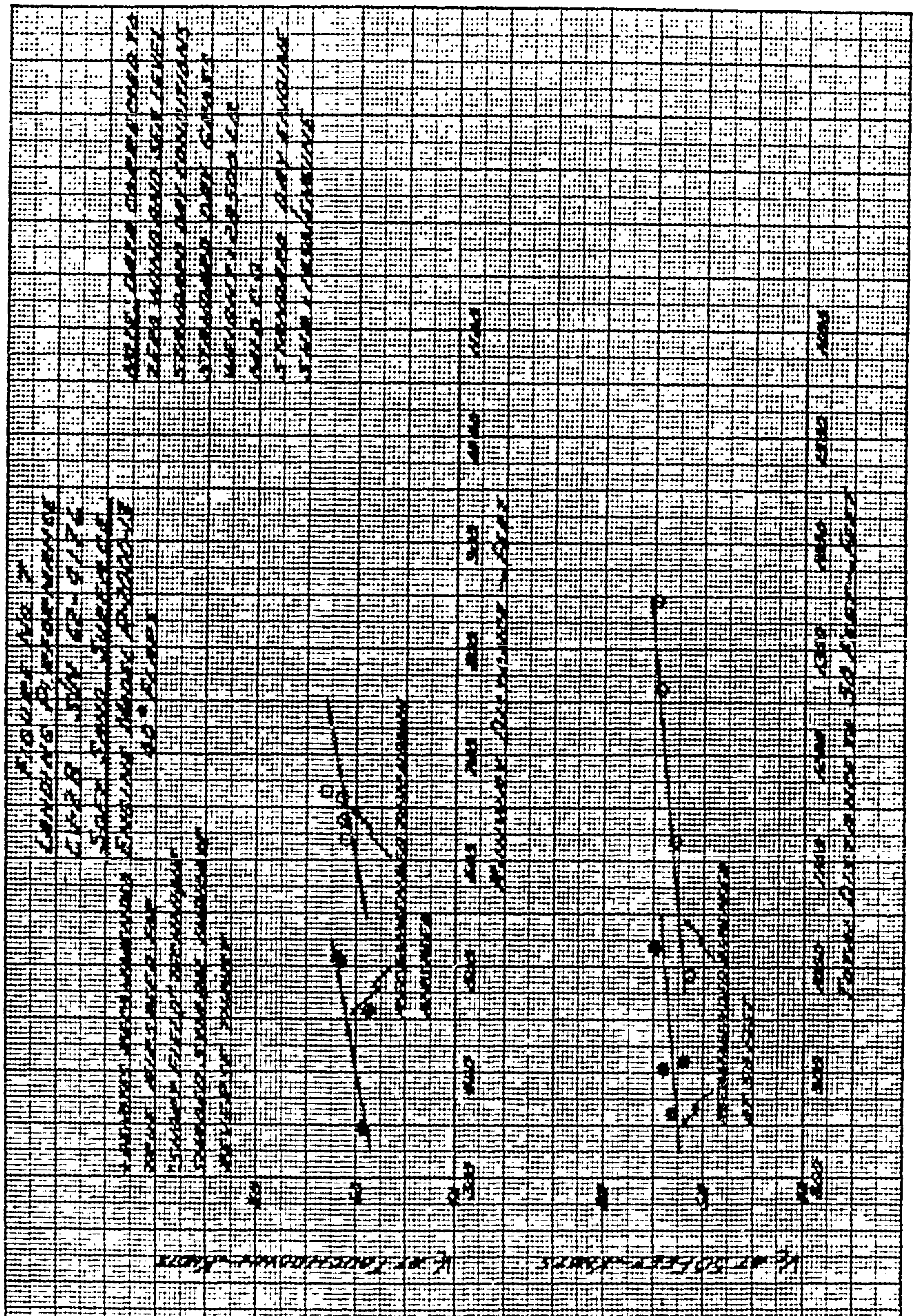


FIGURE NO. 6
LANDING PERFORMANCE
REVERSE THRUST
RUNWAY DISTANCE — FEET
TOTAL DISTANCE TO 50 FEET — FEET



PART III ANNEXES

ANNEX A

SITE SELECTION, SOIL MEASUREMENTS AND ANALYSIS

INTRODUCTION

1. The U.S. Army Engineer Waterways Experiment Station (WES) was requested by the U.S. Army Aviation Test Activity (USAATA), Edwards Air Force Base, California, by telephone message dated 9 July 63, to assist in the selection of off-runway test sites, make soil measurements and analysis in connection with a test program to determine takeoff and landing capabilities of the Caribou CV-2B aircraft on unprepared surfaces. The investigation reported herein concerned the selection of test sites and the obtaining of necessary soils data to evaluate the strength of soils at test sites and the effect of aircraft operations on the soil strength. Mr. Cecil D. Burns, Civil Engineer, represented the WES in this program and prepared this Annex.

TEST SITES

2. One objective of the over-all program was to obtain performance data for the CV-2B aircraft on unprepared surfaces which could be compared directly with the performance of the C-123 and C-130 type aircraft as obtained from the Rough Road Alpha Test Program conducted by the USAF during FY 1963. (1) AFFTC TDR No. 63-8, "Project Rough Road Alpha Take-off and Landing Capabilities of C-130B, JC-130B, NC-130B (BLC), C-123B, and YC-123H Aircraft on Off-Runway (Unprepared) Surfaces." (2) U.S. Army Engineer Waterways Experiment Station TR No. 3-624, "Aircraft Operations on Unsurfaced Soil, Soil Measurements and Analyses Project Rough Road Alpha." Therefore, it was desirable to utilize the same unprepared test sites with as nearly as possible the same surface conditions and soil strength as existed during the Rough Road Alpha tests. The two unprepared test sites utilized were located at Harper Lake, California, and the MCAS, Yuma, Arizona.

Harper Lake - Clay Test Site:

3. The actual test runway utilized in the Rough Road Alpha test was badly rutted and chopped up from previous operations of the C-123 and C-130 aircraft. Therefore, in order to obtain about the same initial conditions for test with the CV-2B aircraft as existed for the initial conditions for test with the CV-2B aircraft as existed for the Rough Road Alpha test, a new runway 1000 feet long was laid out adjacent to and approximately parallel to the northwest end of the runway used in the Rough Road Alpha test. The terrain and soil conditions were essentially identical to that described in the Rough Road Alpha Report (Reference 2). The soil strength was evaluated with an airfield penetrometer (photograph 1) using the same techniques as described in the referenced report. The airfield penetrometer readings indicated the soil strength to be quite uniform for the entire test area for depths of 2 to 18 inches. The surface material consisted of a dry soft crust, of 1 to 2 inches in depth, having little or no measurable strength. Based on a correlation of airfield index and California Bearing Ratio (CBR) developed during the Rough Road Alpha test, the initial CBR of the subgrade for the 6 to 12 inches depth was within the range of 2.3 to 3.7. These values are within the lower ranges of the CBR values measured during the Rough Road Alpha test.

MCAAS, Yuma, Arizona - Sand Test Site:

4. A test runway 2000 feet long was laid out between station 0+00 and station 20+00 of the runway used in the Rough Road Alpha project. This runway was physically the same as used in Project Rough Road Alpha, although the full length of the original runway was not utilized for test with the CV-2B airplane. The soil was a poorly graded to well-graded sand supported very little vegetation. The area was relatively smooth except for bumps and depressions caused mostly by sand mounds and gopher holes ranging from 6 to 10 inches in depth or height. The surface contained a considerable amount of partially buried debris (rocks, tow cables, etc.). The maximum longitudinal and transverse grades were estimated to be about 3 percent. At the end of the Rough Road Alpha program, this area was badly rutted with longitudinal ruts of 12 to 15 inches deep. Prior to

tests with the Caribou aircraft, many of the ruts were still prevalent over the area, while others were filled with loose sand. The sand had stabilized somewhat from the loose state that existed at the end of the Project Rough Road Alpha. The initial CBR for the 6 to 12 inch depth as determined from Airfield penetrometer readings was within the range of 2.4 to 4.2. Based upon the behavior of the sand during the Rough Road Alpha test, it was anticipated that the sand would loosen rapidly under aircraft traffic and that the strength would decrease.

PHOTO 1 - MEASURING SOIL STRENGTH WITH AN AIRFIELD PENETROMETER

TESTS AND RESULTS

Harper Lake - Clay Test Site:

5. The CV-28 aircraft was operated at Harper Lake with maximum gross weight of 28,500 pounds. The main gear was equipped with 11.00-12 type III tires inflated to 40 psi. The nose gear was equipped with 8.50-10 tires inflated to 37 psi. A total of 30 cycles of operations, (30 landings and 30 takeoffs), were made. All aircraft operations were confined to a runway width of 50 feet with about 95 percent of the operations fairly evenly distributed over the center 40 feet of runway.

6. Soil strength determinations made prior to, during, and at the end of aircraft operations showed the soil strength to be quite uniform for the entire runway and to remain essentially constant throughout the period of test. The total range in CBR as determined with an airfield penetrometrometer for the 6 to 12 inch depth was 2.1 to 3.7 with an average CBR of about 3. A summary of the test data is shown in table 1. This is essentially the same soil strength as existed in the northwest end of the runway used in the Rough Road Alpha program.

7. Taxi and takeoff operations resulted in only shallow rutting of less than 2 inches. Landings with maximum effort stops (braking and reverse propellers) resulted in rutting of 4 to 5 inches during the initial operations. A general view of runway after 13 cycles of operations is shown in photograph 2. The condition of the runway surface seemed to improve with continued operations. By the end of 30 cycles of operation, most of the loose crust had consolidated or blown off, photographs 3 and 4, and the runway area was relatively smooth with a few residual ruts in the order of 1 to 3 inches deep.

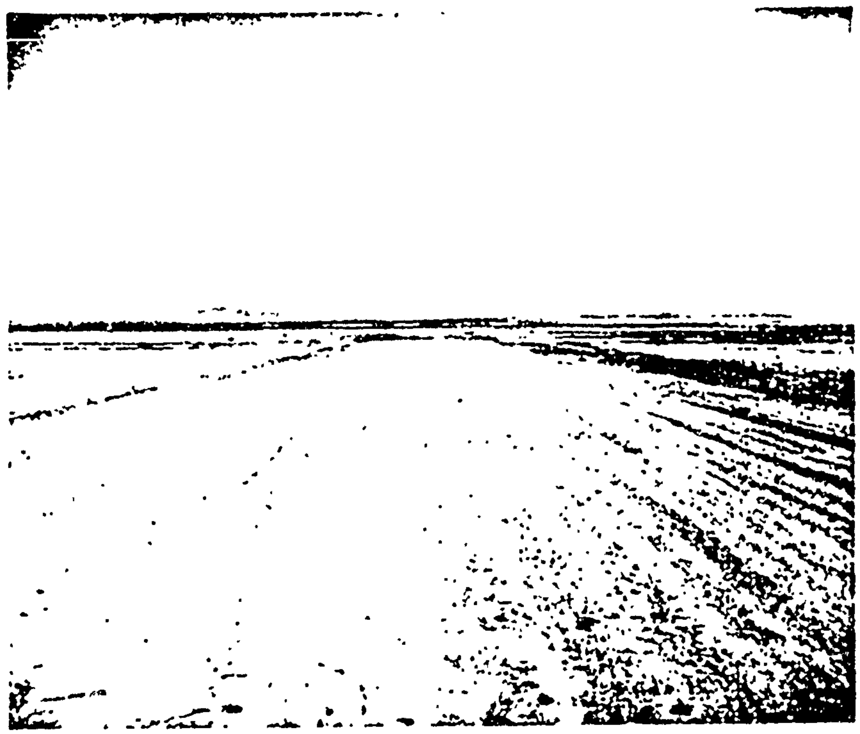


PHOTO 2 - VIEW OF RUNWAY AFTER 13 CYCLES OF OPERATIONS

PHOTO 3 - VIEW OF RUNWAY AFTER 30 CYCLES OF OPERATIONS

PHOTO 4 - TAKEOFF BLAST AREA AFTER 30 CYCLES OF OPERATION (CLAY)

MCAAS, Yuma, Arizona - Sand Test Site:

8. CV-28 aircraft Serial Number 62-4175 made six landings and takeoffs on 30 July 1963. For these operations, the 8.50-10 tires were used on the nose gear. No heavy braking or reverse propellers were used during landings, and no difficulties were encountered in operating the aircraft on the sand. Maximum disturbance of the sand subgrade occurred during turning and maneuvering the aircraft. During turns there was a tendency for the nose gear to dig in, leaving ruts in the sand of 4 to 5 inches deep. On 31 July, the same aircraft made seven cycles of operations in the same area of the runway. For these operations, the nose gear of the aircraft was equipped with smaller tires, 7.50-10. For some of the landings, braking and reverse propellers were used. There were no difficulties encountered in takeoff and landing, although heavy braking did result in rutting of from 4 to 8 inches deep. However, the aircraft with the smaller nose gear tires was more difficult to turn and maneuver on the sand than when using the larger tires. In several instances, the plane was immobilized during taxi turns in ruts 6 to 10 inches deep. The immobilization resulted from the nose gear digging into the sand and pushing sand forward in front of the nose gear (photograph 5.) After each immobilization, the plane was taxied out of ruts after removing sand from in front of the nose gear.

9. Aircraft Serial Number 62-4176 was operated on the sand subgrade for a total of seven cycles on 1 August 1963. The nose gear of this aircraft was equipped with the 8.50-10 tires. Maximum braking and reverse propellers were used during some of the landings. There were no difficulties encountered in operating the aircraft and no immobilization resulted. The average depth of rutting from braking was in the order of 5 to 6 inches. However, in some instances, deeper ruts were made as shown in photograph 6.

10. A total of 20 landings and 20 takeoffs were made on the sand test runway. These operations were fairly well distributed over a width of 40 feet. Soil strength measurements were made prior to operation at the end of 13 and 20 cycles. The soil strength was measured with an airfield penetrometer, and the equivalent CBR values were determined using a correlation of CBR and airfield index, which was developed during the Rough Road Alpha test program. These data are shown in table 2. As can be noted, the strength of the sand decreased quite rapidly with continued aircraft traffic. By the end of 20 cycles of operation the top 12 inches of sand was thoroughly loosened and the indicated average CBR for the 6 to 12 inch depth was within the range of 0.8 to 1.8. This strength is within the same range that existed at the end of the Rough Road Alpha program.

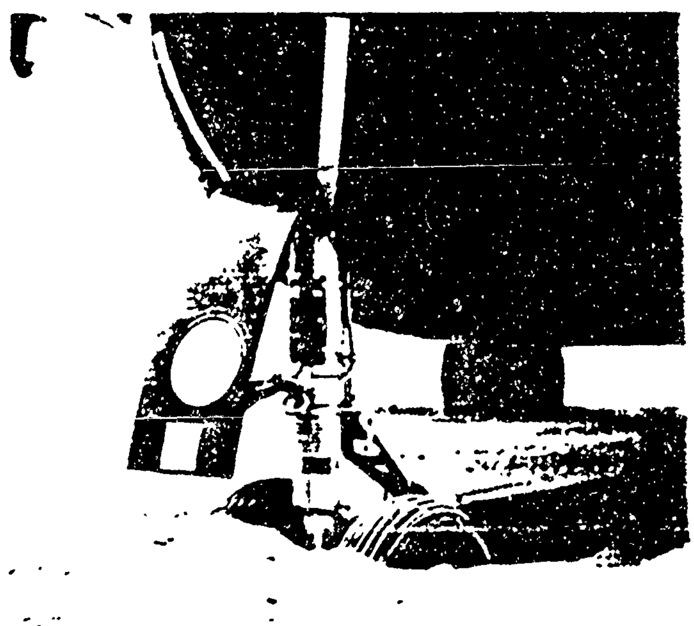


PHOTO 5
IMMOBILIZATION DUE TO RUTTING
AND SAND BUILDUP (SAND)

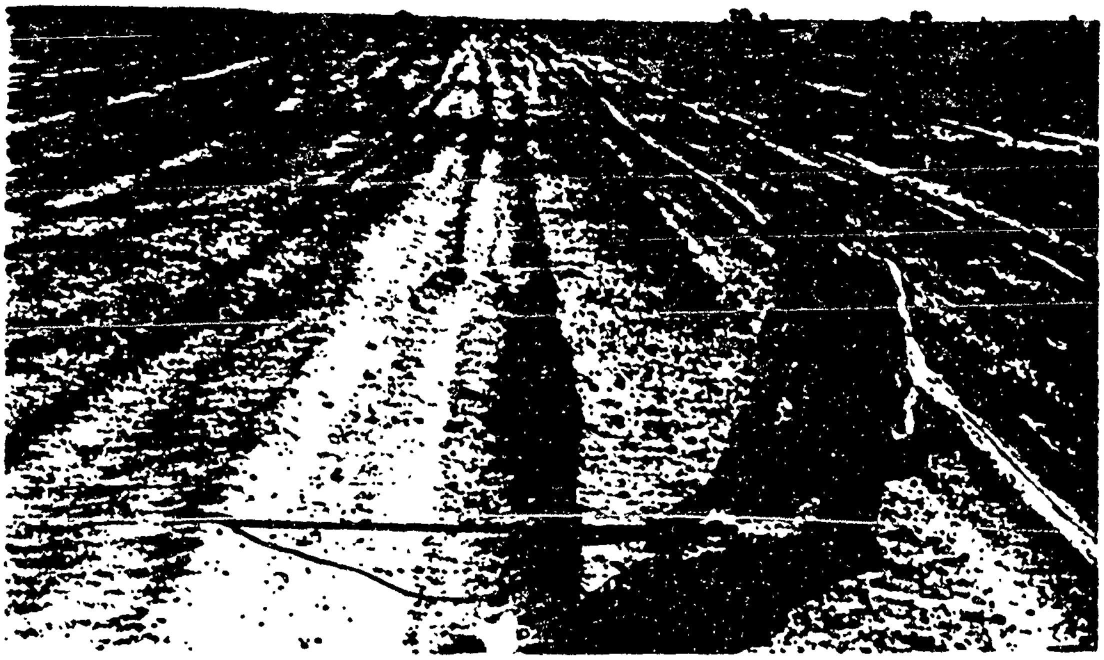


PHOTO 6 - RUTTING RESULTING FROM BRAKING

ANALYSIS OF TEST RESULTS

Harper Lake - Clay Test Site:

11. As previously stated, the CBR of the clay subgrade at Harper Lake ranged from about 2.1 to 3.7 with an average of about 3. Since there were no difficulties encountered in the operation of the CV-2B aircraft on this runway, the minimum soil strength from which the aircraft can operate was not established. However, the aircraft performance and soil behavior appear to be in very good agreement with soil strength criteria for aircraft operations on unprepared landing strips which have previously been developed at the WES. The strength criteria shown in plate 1, with the exception of the curve for a 6-kip wheel load, were taken from plate 3 of WES T.R. No. 3-554, "Validation of Soil-Strength Criteria for Aircraft Operations on Unprepared Landing Strips," dated July 1960. The curve for a 6-kip wheel load was extrapolated in order to cover the wheel loading of the CV-2B aircraft. The CV-2B aircraft is equipped with tricycle landing gear with twin wheel assemblies on both the main and nose gear. Assuming 85 percent of the total gross weight (28,500

pounds) to be carried on the main gear, each main gear is loaded to about 12,000 pounds or 6,000 pounds per wheel. The example of strength (CBR) required in plate 1 is for the CV-2B aircraft loaded to 28,500 pounds with main gear tire pressure of 40 psi. From this example it can be noted that a CBR of 2 is indicated as the required strength for 1 coverage of the aircraft wheels. The average CBR of the clay soil at Harper Lake was 3. By following the slope of the lines on right hand plot of plate 1 (coverages Vs CBR) it can be noted that a CBR of 3 should support about 11 coverages of the Caribou aircraft. The term coverage as used herein referes to one application of a wheel load over a given area.

12. For comparison with the strength criteria shown in plate 1 the aircraft cycles at Harper Lake were converted to coverages based on a tire print width of 8 inches (which was measured on a paved surface) and assuming a uniform lateral distribution of traffic over a 40 foot width of runway. This resulted in 0.2 coverage per aircraft cycle (one takeoff and one landing) or a total of 6 coverages on the clay site. These computations along with the criteria shown on plate 1 indicates that the runway at Harper Lake would have sustained an additional 25 cycles of operations before any major repair or maintenance would be required.

MCAAS, Yuma, Arizona - Sand Test Sites:

13. By use of the same conversion procedure as discussed in the preceding paragraph, the traffic cycles applied on the sand runway resulted in about four coverages over the center 40 feet of runway. The average CBR of the sand for the 6 to 12 inch depth at the end of four coverages (40 cycles) was about 1.0. This is less than the indicated minimum CBR required to support one coverage of the aircraft based on the criteria shown in plate 1. However, the strength of the sand is primarily a function of internal friction and will increase as the degree of confinement increases. The effective strength of the loose sand over the low pressure aircraft tires was adequate to support the aircraft and was greater than indicated by the CBR values. By the end of test operations, the sand was thoroughly loosened to a depth of 12 to 18 inches, and from the standpoint of mobility, it is believed to represent the most severe condition that is likely to be encountered in sand. Generally, mobility in sand will improve with an increase in moisture content. Therefore, it is believed that from the standpoint of soil strength, the CV-2B aircraft can be operated on any sand except on sand when in quick condition. The operations will become more difficult as rutting of the sand surface progresses, and the number of operations or coverages which can be applied over a given runway area will not be limited by soil strength but by the development of rutting and the ability to maneuver the aircraft on the sand in short radius turns in any cross ruts. For the Yuma test site, it is believed that at least as many cycles or coverages of operation could be applied on the surface as estimated for the clay site at Harper Lake with little or no difficulty.

CONCLUSIONS

14. From the data presented herein, the following conclusions are believed warranted.

a. The CV-2B (Caribou) aircraft can operate with maximum gross weight of 28,500 pounds and main gear tire pressure of 40 psi on a clay subgrade where the subgrade CBR is 2.0 or more.

b. The clay subgrade at Harper Lake with an average CBR of three will support about 11 coverages of the CV-2B aircraft at maximum gross weight of 28,500 pounds and main gear tire pressure of 40 psi.

c. The CV-2B aircraft can operate on any sand area (with the exception of quicksand) at maximum gross weight of 28,500 pounds and a main gear tire pressure of 40 psi where the terrain and other surface factors are acceptable.

d. The number of aircraft coverages which can be applied over a soft loose sand subgrade will depend only upon the development of rutting and the ability to maneuver the aircraft on the ground. For the Yuma test site, it is estimated that at least 11 coverages could have been applied with little or no difficulty.

e. The CV-2B aircraft has better flotation and maneuverability on loose sand when nose gear is equipped with 8.50-10 tires than when equipped with smaller 7.50-10.

TABLE I

CV-2B AIRCRAFT OPERATION AND SUBGRADE EVALUATION

Clay Test Area
Harper Lake, California

R.W. Station	Cycles of Operation	Rut Depth In.	Airfield Index at Depth Shown, In. 0	2	4	6	8	10	12	Subgrade Soil Index*	Rating** Equiv. CBR
0+00	0	0	0	5	6	6	6	6	6	6	3.7
	13	1-3	3	6	6	5	6	6	7	6	3.7
	30	1-2	5	4	3	3	4	5	6	4.5	2.7
2+00	0	0	0	4	4	3	3	4	5	4	2.4
	13	2-4	4	4	3	3	3	5	5	4	2.4
	30	1-2	0	6	5	4	4	4	5	4.2	2.5
4+00	0	0	0	5	5	5	5	5	6	5.2	3.1
	13	2-4	2	5	4	4	4	6	6	5	3.0
	30	1-2	2	6	5	5	5	5	5	5	3.0
6+00	0	0	0	4	4	5	6	6	7	6	3.7
	13	2-5	0	5	5	5	6	6	7	6	3.7
	30	1-3	0	5	5	5	5	6	7	5.6	3.4
8+00	0	0	0	5	6	6	6	6	6	6	3.7
	13	2-5	0	5	6	5	5	6	6	5.5	3.3
	30	1-3	0	4	4	4	4	4	6	4.5	2.7
10+00	0	0	0	2	2	3	4	4	4	3.8	2.3
	13	2-4	0	2	4	4	4	4	5	4.2	2.5
	30	1-3	0	4	4	3	3	3	4	3.2	2.0

Notes: All Airfield Index Values tabulated are average of 5 or more penetrometer readings.

* The Soil Index Values shown are the numerical average of airfield index values for the 6, 8, 10, and 12 inch depths.

** Equivalent CBR obtained from correlation of Soil Index and CBR established during Rough Road Alpha test.

TABLE 2

CV-2B AIRCRAFT OPERATION AND

SUBGRADE EVALUATION

Sand Test Site
Yuma MCAS, Arizona

R.W. Station	Cycles of Operation	Rut Depth In.	Airfield Index at Depth Shown, In. 0	2	4	6	8	10	12	Subgrade Soil* Index	Rating Equiv.** CBR
0+00	0	-	0	1	3	6	8.5	11	12	9.5	4.2
	13	2-6	0	0	1	2	4	6	8	5.0	2.1
2+00	0	-	0	1	2	4	6	6	6	5.5	2.5
	13	2-4	0	0	0	1	3	3	4	2.8	1.1
4+00	0	-	0	1	2	4	5.6	6	6	5.4	2.4
	13	2-8***	0	0	1	1	2	4	5	3.0	1.2
6+00	0	-	0	2	3	5	7	8	9	7.2	3.2
	13	2-6	0	0	0	1	2	3	5	2.8	1.1
8+00	0	-	0	1	3	4	5	7	7	5.6	2.6
	13	2-6	0	0	0	2	3	5	6	4.0	1.6
10+00	0	-	0	0	2	6	8	12	13	9.8	4.1
	13	2-4	0	0	0	2	5	10	13	7.5	3.2
	20	2-5	0	0	0	1	2	3	4	2.5	1.0
12+00	0	-	0	0	4	6	7	10	11	8.5	3.8
	13	2-4	0	0	1	3	5	7	8	5.8	2.5
	20	2-5	0	0	0	1	2	3	2	2.2	0.9
14+00	0	-	0	1	3	5	8	9	10	8.0	3.5
	13	2-5	0	0	0	1	2	4	5	3.0	1.2
	20	2-5	0	0	0	1	2	3	5	2.2	0.9
16+00	0	-	0	1	2	5	6	8	8	6.8	2.9
	13	2-6	0	0	0	1	2	4	6	3.2	1.3
	20	2-6	0	0	0	1	1	2	2	1.5	0.8
18+00	0	-	0	0	2	4	8	11	12	8.8	4.0
	13	2-5	0	0	0	1	3	6	10	5.0	2.1
	20	2-5	0	0	1	1	2	3	5	2.8	1.1

(continued)

CV-2B AIRCRAFT OPERATION AND SUBGRADE EVALUATION

Pond Test Site, Yuma MCAAS, Arizona

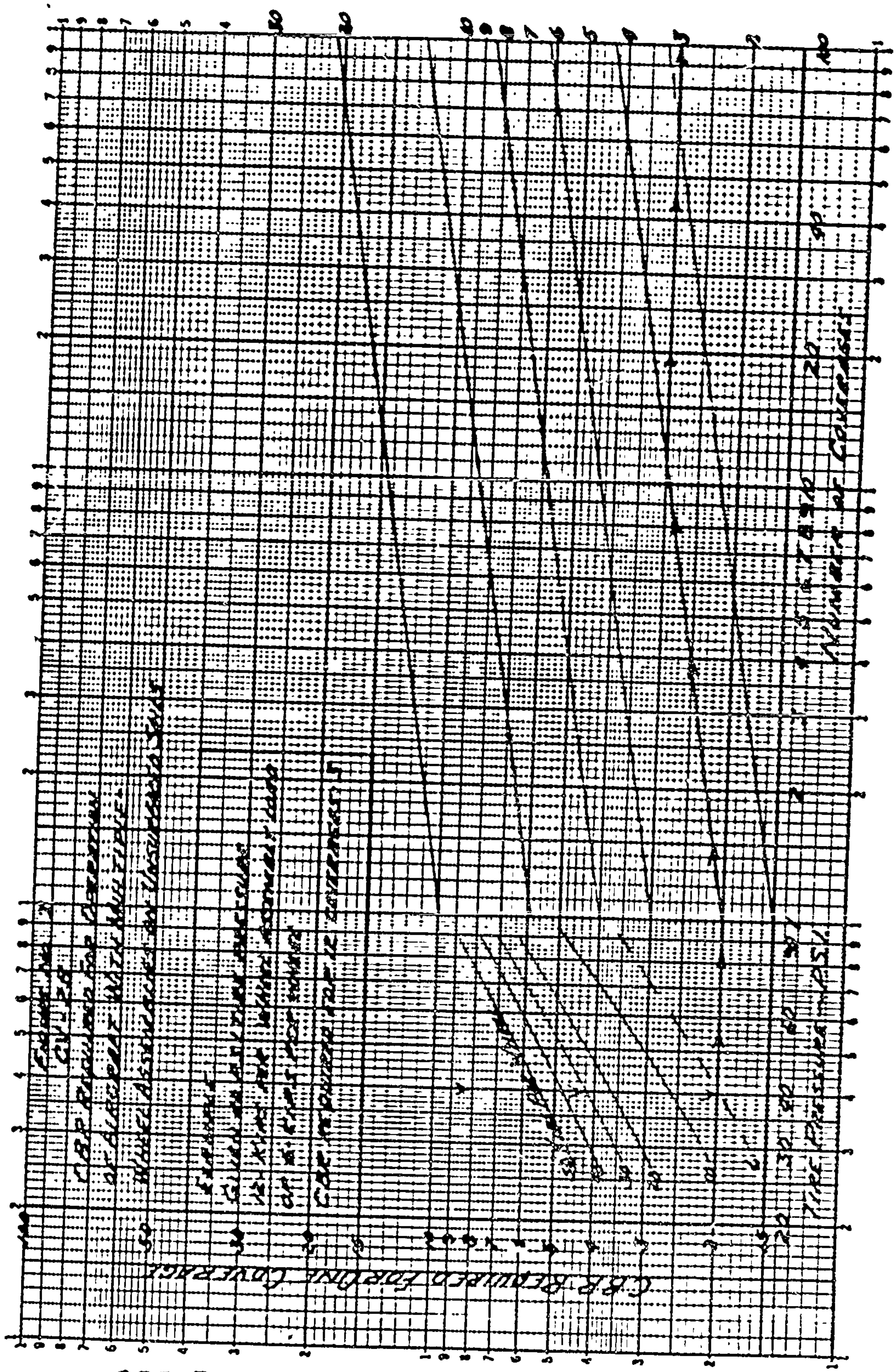
R.W. Station	Cycles of Operation	Rut Depth In.	Airfield Index at Depth Shown, In. 0	2	4	6	8	10	12	Subgrade Soil* Index	Rating Equiv.** CBR
20+00	0	-	0	1	6	12	13	14	15	13.5	6.0
	13	1-3	0	0	1	2	4	8	12	6.5	3.0
	20	2-4	0	0	1	2	3	5	6	4.0	1.8

Notes: All Airfield Index Values tabulated are average of 5 or more penetrometer readings.

* The Soil Index Values shown are the numerical average of airfield index values for the 6, 8, 10, and 12 inch depths.

** Equivalent CBR obtained from correlation of Soil Index and CBR established during Rough Road Alpha test.

*** Immobilized.



CBR Required For Indicated Number of Coverages

ATA-TP-63-9

PLAN OF TEST FOR THE

CV-2B TAKEOFF AND LANDING EVALUATION, PHASE III

U. S. ARMY
AVIATION TEST ACTIVITY
EDWARDS AIR FORCE BASE, CALIFORNIA
TEST AND EVALUATION COMMAND
ARMY MATERIEL COMMAND
UNITED STATES ARMY

10 July 1963

TABLE OF CONTENTS

PLAN OF TEST FOR THE

CV-2B TAKEOFF AND LANDING EVALUATION, PHASE III

INTRODUCTION

A takeoff and landing evaluation of the CV 2B "Caribou" aircraft will be conducted in the Edwards Air Force Base area and at the Yuma Marine Corps Auxiliary Air Station by the U.S. Army Aviation Test Activity. The test aircraft is scheduled for delivery on or about 15 July 1963.

The proposed flight test program establishes a requirement of ten productive flying hours on the aircraft. This schedule may be adjusted depending upon the addition of other loading and center of gravity configurations which would require additional flight test time for evaluation.

TEST PURPOSE

The purpose of this evaluation is to determine takeoff and landing ground roll distance along with total distance to clear a 50-foot obstacle on two types of unprepared airfields. The surface of these unprepared airfields will consist of sand and soft dry clay with California Bearing Ratio (CBR) ranges of from 2 to 5.*

*California Bearing Ratio (CBR) is a measure of the resistance of soils to penetration; it is determined by comparing the bearing value obtained from a penetration-type shear test with a standard bearing value obtained on crushed rock (average value from tests on a large number of samples). The standard results are taken as 100 percent, and values obtained from other tests are expressed as percentages of the standard.

CONDITION OF THE AIRCRAFT RELATIVE TO TESTS

A. Description

The DeHavilland CV-2B aircraft is a cargo transport, all-metal, twin-engine, high-wing monoplane with fully retractable tricycle landing gear. It is powered by two Pratt and Whitney R-2000-13 radial engines. The sea level standard day engine rating is 1450 brake horsepower per engine at takeoff, 1200 brake horsepower for maximum continuous (normal rated power) and 725 brake horsepower for maximum continuous lean mixture settings. (Each engine is equipped with a three-bladed, reversing, Hamilton Standard hydromatic propeller.)

B. General Dimensions

Overall length	72 ft 7 in
Overall height	21 ft 9 in
Wing span	96 ft ½ in
Wing area (total)	912 sq ft
Fuel capacity	828 U.S. gal
Oil capacity (per engine)	22.2 U.S. gal

C. Design Limitations of the airplane are as follows:

Limit Load Factor (for gross weight of 26,000 lb):

Maneuvering	
Positive	2.9
Negative	-1.5
Landing	2.0

Airspeed Limitations (for gross weight of 26,000 lb):

Never Exceed	212 kts (IAS)
Maximum Cruising Speed	170 kts (IAS)
Maximum Speed (40° flaps)	80 kts (IAS)
Maximum Speed (30° flaps)	85 kts (IAS)
Maximum Speed (gear extended)	120 kts (IAS)

Miscellaneous:

Maximum takeoff gross weight	28,500 lb
Maximum landing gross weight	28,500 lb

D. Weight and Balance

The airplane will be weighed with full oil and full of fuel. The capacity of each fuel tank will be determined by means of calibrated fuel nozzle. The ship's fuel quantity indicators will be calibrated by the same means with the aircraft in a normal three-point attitude.

TEST SUPPORT

A. Logistics

1. Maintenance

The test aircraft will be maintained by the U.S. Army Aviation Test Activity with the aid of military personnel. ATA will be required to furnish all replaced parts, fuel, inspection, etc. ATA personnel will be required to accompany the test aircraft to all test sites.

2. Instrumentation

The following test instrumentation will be required for the CV-2VB. The basic recording equipment will consist of an engineer's panel and oscillpgraph (nine-channel) located in the cargo compartment. Aircraft performance parameters, basic engine parameters and flight condition data will be hand-recorded from the engineer's panel, and C.G. normal and longitudinal acceleration will be recorded on the oscillograph.

The following parameters will be presented:

Engineer's Panel

Boom airspeed

Boom altimeter

Free air temperature

Manifold absolute pressure
(for right and left engines)

Carburetor air temperature
(for right and left engines)

Engine rpm (for right and left engines)

Fuel quantity indicators
(Pilot's Panel)

Oscillograph (nine-channel)

Linear acceleration, longitudinal

Linear acceleration, normal

During the test program, installed instrumentation will be calibrated and supported by ATA personnel.

B. Operations

ATA Flight Operations will provide a project pilot and other test pilots as required during the testing period. A support aircraft will be required at Harper's Lake test site.

C. Engineering

This program will require two engineers, a Fairchild Camera operator, and an engineering aid. The Fairchild Camera operator's services will be required during the operational part of the program while the engineering aid's services are required during the operational and data reduction part of the program. The project engineer will be required until the final report is published. A support engineer will be required during TDY operations to direct and operate the ground station.

D. Outside Support

1. Photo Support

An Air Force photographer will be required during the entire program to take motion pictures and still photographs.

2. Refueling Support

Approximately 1600 gallons of aviation gasoline will be consumed during the project.

TEST PROGRAM

A. Airspeed Calibration

The test airspeed boom system will be calibrated in approximately 10 knot increments over the available airspeed range in the takeoff (30° flaps) and approach (40° flaps) configurations. The calibration will be obtained by utilizing the Edwards AFB Ground Speed Course.

B. Takeoff and Landing Performance (Paved Runways)

Takeoff and landing will be performed on the Edwards AFB South Base paved runway at the following gross weight of 28,500 pounds to obtain base line data for the test aircraft.

C. Takeoff Performance on Unprepared Runways

Fairchild Flight Analyzer recorded takeoffs will be performed from Harper's Dry Lake and Yuma Marine Corps Auxilary Air Station on unprepared surveyed and marked airstrips. A sufficient number of takeoffs, using the "short field" technique, as outlined in TM 55-1510-206-10, will be recorded to determine the maximum takeoff performance using a 30-degree takeoff flap setting at a gross weight of 28,500 pounds. The airspeed at lift-off will be varied over a sufficient range to determine its effect on ground roll and total distance to clear a 50-foot obstacle. These tests will be conducted under calm wind conditions. Takeoff power will be obtained prior to brake release. Data will be corrected to sea level standard day, zero wind conditions.

D. Landing Performance on Unprepared Runways

Landing distances required to clear a 50-foot obstacle and come to a complete stop using the "short field" technique, as outlined in TM 55-1510-206-10, will be recorded using a Fairchild Flight Analyzer. Data will be obtained at 28,500 pounds using a 40-degree landing flap setting. These data will be reduced to sea level standard day and zero wind conditions.

CONCLUSIONS

It is estimated that the execution of the flight test plan outlined in the proposed program will be accomplished in 10 productive flying hours and 15-20 calendar days. Submittal of a letter report will be accomplished approximately 20-30 days after completion of flying.

ATA-TP-63-9

PLAN OF TEST FOR THE

CV-2B TAKEOFF AND LANDING EVALUATION, PHASE III

ADDENDUM A

U. S. ARMY
AVIATION TEST ACTIVITY
EDWARDS AIR FORCE BASE, CALIFORNIA
TEST AND EVALUATION COMMAND
ARMY MATERIEL COMMAND
UNITED STATES ARMY

16 July 1963

PLAN OF TEST FOR THE

CV-2B TAKEOFF AND LANDING EVALUATION, PHASE III

ADDENDUM A

INTRODUCTION

A CV-2B aircraft instrumented for landing gear loads under unprepared field conditions will be tested by the U. S. Army Aviation Test Activity. The aircraft is scheduled for delivery on or about 19 July 1963.

PURPOSE

The purpose of this test will be to duplicate the performance landings and takeoffs of the CV-2B discussed in the basic plan of test to determine if landing gear loads impose a limit on the performance of the aircraft during unprepared airfield operation.

SCOPE

The tests with the structurally instrumented aircraft will as near as possible duplicate the test conditions of the performance aircraft. In addition, prior to the performance takeoffs and landings in the soft sand at Yuma, a structurally monitored buildup program will be conducted with the structurally instrumented CV-2B. The gear loads will be monitored while the gross weight of the aircraft is increased to determine possible structural operating limits for the performance aircraft.

WEIGHT AND BALANCE

The same weight and balance and fuel flow calibration schedule utilized for the performance aircraft will be conducted on the structural aircraft.

TEST SUPPORT

It is anticipated that the structural aircraft will be flown concurrently with the performance aircraft.

A. Logistics

1. Maintenance

The same maintenance arrangements as for the performance aircraft will be employed on the structural aircraft.

2. Instrumentation

Ten strain gages and normal (a_z) and longitudinal (a_x) accelerometers are being installed by the airframe manufacturer.

It is expected that ATA personnel will maintain this instrumentation.

Additional instrumentation to be installed will probably be minor and will be determined after the arrival of the aircraft. A sensitive calibrated airspeed indicator and altimeter will probably be all that is required.

B. Operations

An Aviation Board engineering test pilot and a Board copilot will fly the test aircraft under the direct control of the ATA project engineer.

C. Engineering

An additional two engineers will be required to support this project.

D. Outside Support

No additional support will be required other than an additional 1600 gallons of fuel.

CONCLUSIONS

It is estimated that the execution of the flight test plan outlined in the proposed program will be accomplished in 15 productive flying hours and 15 to 20 calendar days. Submittal of a letter report will be accomplished approximately 20 to 30 days after completion of flying.

ANNEX C

REFERENCES

1. FTC-TDR-63-8, "Project Rough Road Alpha Take-off and Landing Capabilities of C-130B, JC-130B, NC-130B (BLC), C-123B, and YC-123H Aircraft on Off-Runway (Unprepared) Surfaces," April 1963.

2. AFFTC-TR-60-41, "YAC-1DH Category II Performance and Stability Tests," November 1960.

3. AFFTC-TN-R-12, "Standardization of Takeoff Performance Measurements for Airplanes," by K. J. Lush.

4. USAF-TR-6273, "Flight Test Engineering Manual."

5. Technical Report No. 3-624, "Aircraft Operations on Unsurfaced Soil, Soil Measurements and Analysis Project Rough Road Alpha," June 1963, by U. S. Army Engineering Waterways Experimental Station, Corps of Engineers, Vicksburg, Miss.

6. TO 55-1510-206-20, "Organizational Maintenance Manual, CV-2 Aircraft."

ANNEX D

KEY PERSONNEL INVOLVED IN THE CARIBOU TAKEOFF AND LANDING TESTS

Name	Rank	Organization
John C. Kidwell	Civ	U. S. Army Avn Test Actv
John T. Blaha	Civ	U. S. Army Avn Test Actv
Rodger L. Finnestead	Civ	U. S. Army Avn Test Actv
Michael M. Antoniou	Capt	U. S. Army Avn Test Actv
Paul Bankit	Capt	U. S. Army Avn Test Board
Richard J. Followill	Civ	U. S. Army Avn Test Board
James S. Kishi	Civ	U. S. Army Avn Test Board
A. K. Stewart	Lt Col	Hq, CDCEC, Fort Ord, Calif.
John A. Bauer	Civ	U. S. Army AVSCOM, St. Louis, Mo.
Raymond J. Cantu	Civ	U. S. Army AVSCOM, St. Louis, Mo.
Arthur E. Cox	Civ	U. S. Army AVSCOM, St. Louis, Mo.
E. Bowers	Civ	DeHavilland Aircraft
John Thompson	Civ	DeHavilland Aircraft
Gerald F. Healey	Civ	Hamilton Standard

AD ____________ Accession No. ____________
U.S. Army Aviation Test Activity, Edwards AFB, California PERFORMANCE TEST OF TAKEOFF AND LANDING CAPABILITIES OF THE CARIBOU CV-2B AIRCRAFT ON UNPREPARED SURFACES, by John C. Kidwell. Final Report ATA-TR-63-4, September 1963. USATECOM Project 4-4-1141-01.

50 pp, 8 tables, 11 photographs, 8 figures Unclassified Report. Tests were conducted to determine the performance of CV-2B airplanes when utilizing unprepared surfaces and environments similar to those encountered during the Air Force Project Rough Road Alpha. It was concluded that the takeoff and landing performance of the CV-2B, when operating at its maximum gross weight of 28,500 pounds, is better than that of the C-130B and the C-123B and equal to or better than that of

(over)

Unclassified

1. CV-2B Performance on Unprepared Surfaces.
2. John C. Kidwell
3. ATA-TR-63-4

Unclassified

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3. ATA-TR-63-4

Unclassified

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